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ON THE ETIOLOGY OF DENGUE FEVER

Thomas L. Bancroft

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influence on the excitability or stimulus production, or both, in this region. As to the nature of this influence, we are ignorant.

The fact that while taking digitalis the pulse rate increased from 32 to 46 or 50 beats per minute is of interest, as is also the fact that the venous pulse in the neck now appeared from inspection to take the form of two waves to one arterial, suggesting that now each auricular contraction was followed by a ventricular. In the absence of a graphic record of the venous pulse at this time it is unsafe to attempt its explanation.

Mackenzie (*B.M.J.*, 8-4-05) argues that where the inception of the rhythm of the heart is due to the ventricle, the effect of digitalis is to depress contractility. In the cases he cites, though there is no evidence of auricular contraction, it is possible that the stimulus originated in the sinus was conducted through the auricles without causing measurable contraction, and caused contraction of the ventricles. Engleman has shown that this may occur experimentally.

In the case under consideration, where the ventricles were originating their own rhythm, the effect of digitalis appeared to be to increase the rate and strength of contraction, which does not accord with depression of contractility. That potassium iodide in five grain doses was given at the same time must be remembered in deciding the part played by digitalis in increasing the pulse rate.

Mackenzie, in his case of independent action of the auricle and ventricles, found the ventricular rate to be remarkably cut off from external influences, and Wenckebach found in a similar case that wine accelerated the auricular rate but did not affect the ventricles.

Time will not permit of the discussion of other interesting points in this case, the meaning of the extra sounds heard in the veins, and the degeneration of the suprarenals. Already I fear I have wearied you with details which you may consider far removed from the domain of practical medicine. My excuse must be that the case interested me to such an extent that I hoped it might prove of some interest to you all, and that any attempt is justifiable to fathom that great mystery—the cause of heart action and failure, even if it only takes the form of confirming work already done by others.

(Read before the New South Wales Branch of the British Medical Association).

ON THE ETIOLOGY OF DENGUE FEVER.*

By Thomas L. Bancroft, M.B. (Edin.), Brisbane.

THE recent epidemic of dengue fever in Queensland has afforded opportunity to make some observations on the etiology of the disease. Although nothing of a decided nature was ascertained, still I consider the results of the investigation should be recorded.

Dengue fever, although a virulently infectious disease, differs in its contagiousity markedly from influenza, measles, etc., direct contact with a person suffering from the disease—*e.g.*, sleeping in the same bed with him—does not suffice to convey the infection; there must then be some intermediary agent, and the question arises, is this an insect? Dr. Graham,¹ working on dengue in Syria, satisfied himself that an intermediary host was required. He experimented with the two notoriously bad mosquitoes of warm latitudes, viz., the *Culex fatigans* and the *Stegomyia fasciata*, and came to the conclusion that the former was the offending insect. Still he admits that in all his experiments there were some *stegomyiæ* also present among his mosquitoes. To me he seems to have proved absolutely that mosquitoes can convey the disease, for he caught a number which had imbibed dengue blood, and carried them to a village outside the epidemic area. They were allowed to bite two men, both of whom afterwards got dengue within the incubation period, that is, three to six days. Unfortunately, he gives no details of his work which would assist anyone endeavouring to verify it. Graham states that he found an intra-corpuscular parasite in the red blood corpuscles of persons suffering from dengue. It resembled *piroplasma bovis*, the protozoon of Texas fever or bovine redwater. Eberle² also states that in dengue there is an intra-corpuscular organism. I have not been able, however, to see an intra-corpuscular parasite; neither have I found any bacterium³ that would grow on agar inoculated with dengue blood, and am inclined to consider that the organism of dengue is ultra-microscopic. The two suspected mosquitoes occur plentifully in Brisbane and suburbs; *stegomyiæ*, however, are absent from isolated houses. Some people living in the country, and having

*This paper was received in time for insertion in our issue of August last, but owing to pressure on our space has been held over.

visited friends ill with dengue in Brisbane during the daytime, acquired the disease, which demonstrates that if dengue is a mosquito-borne disease at all, the *Stegomyia fasciata* at least is an efficient host, for that insect is diurnal in habit, whereas the *Culex fatigans* is strictly nocturnal.

As Graham had given no methods, I took, as a working hypothesis, the experience of the American investigators respecting yellow fever.⁴ Yellow fever is a disease, in many respects, allied to dengue. The organism of yellow fever in human blood is ultra-microscopic—so small indeed as to be capable of passing through a Berkefeld filter. It undergoes a metamorphosis in the stomach and salivary glands of *Stegomyia fasciata*. This metamorphosis can be observed microscopically. It is necessary in order to infect mosquitoes to allow them to imbibe the blood of a yellow fever patient during the first three days of the disease. Before these mosquitoes are capable of infecting non-immunes a period of 12 days at least must elapse. The following experiments were made on men:—

CASE 1.—A number of *stegomyiæ*, distended with blood, were captured in the bedroom of a house in which two persons were ill with dengue and did not use a mosquito net curtain. A third person slept there, who was healthy. These mosquitoes were kept in suitable boxes and fed on dates; twelve days afterwards 25 of them were allowed to bite the third person previously mentioned, a man, G.G., aged 34, in perfect health. Up to five days afterwards his temperature remained normal, and he felt no ill effects whatever; but on the commencement of the sixth day he was taken suddenly with a severe rigor and pain in the loins, and his temperature went up to 101° F. He was ill for several days with a mild but typical attack of dengue.

CASES 2 AND 3.—Two men, aged respectively W.M. 18, C.F. 30 years, were each bitten by five *stegomyiæ* (mosquitoes reared by me and allowed to bite a person with dengue on the third day of the disease). Fifteen days had elapsed since the mosquitoes had imbibed the dengue blood. These men never developed any symptoms. They were residing with their friends, who had had the disease some time before. W.M. was the only one of a family of ten who did not take the disease.

CASE 4.—J. O'K., a man aged 29, from the country, lived with friends in Brisbane, who had had dengue some weeks before. A week after residing in Brisbane he submitted himself for experiment. Fifteen *stegomyiæ*, which had imbibed, ten days before, blood from a dengue case in the second day of the disease, bit him. At the commencement of the fifth day his temperature went up to 101.3° F., and he complained of headache, nausea, sleeplessness, and other symptoms of dengue. He had no doubt a mild attack of the disease.

CASE 5.—J.J., a labourer, aged 58, working for me, resided in my laboratory and slept under mosquito net at night for ten days before experiment. There were no free *stegomyiæ* but a few *Culex fatigans* in this locality. Fifteen *stegomyiæ*, which had imbibed blood on the second day of the disease, 17 days previously, were allowed to bite him. His temperature was taken night and morning for eight days afterwards; it remained normal, and he continues in good health.

The failure in my experiments to transmit the disease I attribute to the mosquitoes having imbibed dengue blood at the wrong time possibly, or to what I believe now to be of more importance, to my having kept them too long before allowing them to bite a susceptible person. The middle gut and salivary glands of a number of both the mosquitoes mentioned, which had imbibed dengue blood 20 days previously, were carefully examined microscopically, but nothing abnormal was noticed. Graham states that the organism of dengue can be seen in the salivary glands.

I am inclined to believe now that the organism of dengue lives but a few days in the mosquito; that were non-immunes bitten within a day or two of the mosquito having imbibed dengue blood a single mosquito could infect; and, further, that were the salivary glands examined early enough, phases of the parasite would probably be seen.

Should dengue occur again with the advent of warm weather I hope to make further investigation on these lines.

Brisbane, July, 1905.

(1) *Journal of Tropical Medicine*, July 1st, 1903.

(2) *New York Medical Journal and Philadelphia Medical Journal*, December 24th, 1904.

(3) *McLaughlin, Journal American Medical Association*, June 19th, 1886.

(4) *Manson's "Tropical Diseases,"* 3rd edition.

